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| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|-----------------|-------------|----------------------|---------------------|------------------|
| 09/739,929      | 12/18/2000  | Thomas N. Marieb     | 42390P10637         | 4878             |

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BLAKELY SOKOLOFF TAYLOR & ZAFMAN  
12400 WILSHIRE BOULEVARD, SEVENTH FLOOR  
LOS ANGELES, CA 90025

[REDACTED] EXAMINER

HOANG, QUOC DINH

| ART UNIT | PAPER NUMBER |
|----------|--------------|
| 2818     |              |

DATE MAILED: 11/30/2001

Please find below and/or attached an Office communication concerning this application or proceeding.

|                              |                        |                     |  |
|------------------------------|------------------------|---------------------|--|
| <b>Office Action Summary</b> | <b>Application No.</b> | <b>Applicant(s)</b> |  |
|                              | 09/739,929             | MARIEB ET AL.       |  |
|                              | <b>Examiner</b>        | <b>Art Unit</b>     |  |
|                              | Quoc Hoang             | 2818                |  |

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

#### Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

#### Status

- 1) Responsive to communication(s) filed on 18 December 2000.
- 2a) This action is FINAL.                  2b) This action is non-final.
- 3) Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

#### Disposition of Claims

- 4) Claim(s) 1-29 is/are pending in the application.
- 4a) Of the above claim(s) \_\_\_\_\_ is/are withdrawn from consideration.
- 5) Claim(s) \_\_\_\_\_ is/are allowed.
- 6) Claim(s) 1-29 is/are rejected.
- 7) Claim(s) \_\_\_\_\_ is/are objected to.
- 8) Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

#### Application Papers

- 9) The specification is objected to by the Examiner.
- 10) The drawing(s) filed on \_\_\_\_\_ is/are: a) accepted or b) objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
- 11) The proposed drawing correction filed on \_\_\_\_\_ is: a) approved b) disapproved by the Examiner.  
If approved, corrected drawings are required in reply to this Office action.
- 12) The oath or declaration is objected to by the Examiner.

#### Priority under 35 U.S.C. §§ 119 and 120

- 13) Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) All b) Some \* c) None of:
1. Certified copies of the priority documents have been received.
2. Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
3. Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- \* See the attached detailed Office action for a list of the certified copies not received.
- 14) Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).
- a) The translation of the foreign language provisional application has been received.
- 15) Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

#### Attachment(s)

- 1) Notice of References Cited (PTO-892)
- 2) Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 3) Information Disclosure Statement(s) (PTO-1449) Paper No(s) \_\_\_\_\_.
- 4) Interview Summary (PTO-413) Paper No(s) \_\_\_\_\_.
- 5) Notice of Informal Patent Application (PTO-152)
- 6) Other: \_\_\_\_\_.

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## **DETAILED ACTION**

### ***Drawings***

1. The informal drawings are not of sufficient quality to permit examination. Accordingly, new drawings are required in reply to this Office action.

Applicant is given a TWO MONTH time period to submit new drawings in compliance with 37 CFR 1.81. Extensions of time may be obtained under the provisions of 37 CFR 1.136(a). Failure to timely submit new drawings will result in ABANDONMENT of the application.

### ***Claim Rejections - 35 USC § 102***

2. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

(e) the invention was described in a patent granted on an application for patent by another filed in the United States before the invention thereof by the applicant for patent, or on an international application by another who has fulfilled the requirements of paragraphs (1), (2), and (4) of section 371© of this title before the invention thereof by the applicant for patent.

3. Claims 1-3 are rejected under 35 U.S.C 102(e) as anticipated over Nogami et al., (US Patent 6,022,808).

With regard to claim 1, Nogami et al., Figure. 1-3, and related text on col. 1-6 which disclose a method of forming a copper interconnect comprising the step of plating a copper layer 13 over a substrate (col. 5, lines 60-65 and Fig. 1); forming a dopant layer 14 over the copper layer 13 (col. 5, lines 60-65 and Fig. 1); driving dopants from the dopant layer 14 into the copper layer 13 (col. 5, lines 65-67 and Fig. 2); and removing the dopant layer 14 (col. 6, lines 1-10 and Fig. 3).

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With regard to claim 2, Nogami et al., disclose the substrate comprises a diffusion barrier layer 11 overlying a dielectric layer 10 (col. 5, lines 55-65 and Fig. 1).

With regard to claim 3, Nogami et al., disclose the diffusion barrier layer 11 comprises a material selected from the group consisting of Ta, TaN, Ti and TiN (col. 5, lines 1-6 and Fig. 1).

***Claim Rejections - 35 USC § 103***

4. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

5. Claims 4-9 are rejected under 35 U.S.C 103(a) as being unpatentable over Nogami et al., (US Patent 6,022,808).

With regard to claim 4, Nogami et al., teach sputter depositing doped copper layer 14 on the undoped copper layer 13, but do not teach plating the doped copper layer on the undoped copper layer (col. 5, lines 64-65). However, it would be obvious to use the teaching of Nogami et al. to deposit a better doped copper layer on the copper layer by sputtering since excellent control of the impurity concentration and crystalline perfection can be achieved.

With regard to claim 5, Nogami et al., teach the metal layer 14 comprises at least one element which when alloyed with Cu improves an electromigration characteristic of Cu (col. 5, lines 20-32).

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With regard to claim 6, Nogami et al., teach the at least one element is selected from the group consisting of Sn, Al, Mg, and Co (col. 5, lines 20-32).

With regard to claim 7, Nogami et al., teach plating the copper layer 13 comprises electroplating (col. 5, line 1).

With regard to claim 8, Nogami et al., teach plating the copper layer 13 comprises electroless deposition (col. 5, line 1).

With regard to claim 9, Nogami et al., teach driving dopants into the copper layer 13 comprises elevating the temperature of the dopant layer 14 and copper layer 13 to between 300°C and 400°C (col. 5, lines 32-55).

#### ***Claim Rejections - 35 USC § 102***

6. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

(e) the invention was described in a patent granted on an application for patent by another filed in the United States before the invention thereof by the applicant for patent, or on an international application by another who has fulfilled the requirements of paragraphs (1), (2), and (4) of section 371© of this title before the invention thereof by the applicant for patent.

7. Claims 10-16 are rejected under 35 U.S.C 102(e) as anticipated over Andricacos et al., (US Patent 6,268,291).

With regard to claim 10, Andricacos et al., Figure. 5A-B, and related text on col. 10 which disclose a method of forming a copper interconnect comprising the step of plating a

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copper layer 100 over a substrate (col. 10, lines 22-32 and Fig. 5B); and implanting at least one dopant element into the copper layer 100 (col. 10, lines 22-32 and Fig. 5B).

With regard to claim 11, Andricacos et al., teach the at least one dopant element is selected from the group consisting Al, Mg, and Sn (col. 12, lines 60-65 and Table 4).

With regard to claim 12, Andricacos et al., teach polishing the copper layer 100 so as to form individual interconnect lines prior to implanting (see Fig. 5B).

With regard to claims 13-14, Andricacos et al., teach depositing a barrier layer 94 over the interconnect lines subsequent to implanting (col. 10, lines 22-40 and Fig. 5B).

With regard to claim 15, Andricacos et al., teach depositing a barrier layer 94 over the interconnect lines prior to implanting (col. 10, lines 22-40 and Fig. 5B)..

With regard to claim 16, Andricacos et al., teach the dopant is implanted into the surface of the copper layer 100 to depth of about 10 monolayers (col. 12, lines 60-65).

***Claim Rejections - 35 USC § 103***

8. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

9. Claims 17-18 are rejected under 35 U.S.C 103(a) as being unpatentable over Andricacos et al., (US Patent 6,268,291).

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With regard to claims 17-18, Andricacos et al., teach the dopant is implanted a dose of 3E15 atoms/cm<sup>2</sup> at an energy of 50-180 keV, but do not teach the dopant is implanted a dose of 3E15 atoms/cm<sup>2</sup> at an energy of 5 keV (see Table 4). The energy claimed is considered an obvious design optimization and do not lend novelty to the claimed process. Also, Andricacos do not teach the dopant is implanted to achieve an implant profile peak at 50 angstroms below the Cu surface and a concentration of 1.5 wt% over 100 angstroms.. The concentration claimed is considered an obvious design optimization It would have been obvious to implant the dopant to the specified concentration to obtain a desired result.

***Claim Rejections - 35 USC § 102***

10. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

(e) the invention was described in a patent granted on an application for patent by another filed in the United States before the invention thereof by the applicant for patent, or on an international application by another who has fulfilled the requirements of paragraphs (1), (2), and (4) of section 371© of this title before the invention thereof by the applicant for patent.

11. Claim 19 is rejected under 35 U.S.C 102(e) as anticipated over Havemann et al., (US Patent 6,130,156).

Regarding claim 19, Havemann et al., Figure. 2c, and related text on col. 5 which disclose a method of forming a copper interconnect comprising the step of depositing a seed layer 29 on a substrate, the seed layer 29 comprising Cu and at least one doping element (col. 5, lines 37-42 and Fig. 2c); forming a capping layer 31 over the seed layer 29 (col. 5, lines 42-43 and Fig. 2c);

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forming a copper layer 33 over the capping layer 31 (col. 5, lines 44-45 and Fig. 2c); and driving the at least one doping element from the seed layer 29 into the copper layer 33 (col. 5, lines 45-60 and Fig. 2c).

***Claim Rejections - 35 USC § 103***

12. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

13. Claims 20-29 are rejected under 35 U.S.C 103(a) as being unpatentable over Havemann et al., (US Patent 6,130,156) in view of Chiang et al, (US Patent 6,160,315).

With regard to claims 20-21, Havemann et al., teach the seed layer 29 and the capping layer 31 are formed sequentially, but do not clearly teach not exposing the seed layer to the atmosphere prior to deposition of the capping layer 31 (col. 5, lines 25-60 and Fig. 2c). However, it would be easy to realize that the capping layer is deposited on the seed layer in order to prevent oxidation of the seed layer.

With regard to claims 22-23, Havemann et al., teach depositing the seed layer 29 comprises sputtering a metal alloy of CuSn (col. 5, lines 38-42).

With regard to claims 24, Havemann et al., teach the capping layer 31 comprises sputtering Cu (col. 5, lines 42-44).

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With regard to claims 25, Havemann et al., teach driving the at least one doping element from the seed layer 29 into the Cu layer using the thermal annealing without teaching the precise temperature ranges as claimed. The temperature claimed is considered an obvious design optimization and do not lend novelty to the claimed process.

Regarding claim 25-29, Chiang et al., Figure. 9, and related text on col. 7-8 which disclose a method of forming a copper alloy interconnect comprising the step of exposing at least the surface of the copper layer 72 to an ambient that reacts with the doping element (col. 7, lines 40-67 and col. 8, lines 1-62 and Fig. 9).

Havemann et al. and Chiang et al. are combinable because they are from the same field of endeavor. At the time of the invention it would have been obvious to a person of ordinary skill in the art to expose the surface of the copper layer to an ambient that reacts with the doping element in order to minimize surface corrosion of the copper layer. Therefore, it would have been obvious to combine Havemann et al. with Chiang et al.

14. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Quoc Hoang whose telephone number is (703) 306-5795. The examiner can normally be reached on Monday -Friday from 8.00 AM to 5.00 PM.

If attempt to reach the examiner by telephone are unsuccessful, the examiner's supervisor, David Nelms., can be reached on (703) 308-4910  
*QH*  
Quoc Hoang  
Examiner  
Group 2818

  
David Nelms  
Supervisory Patent Examiner  
Technology Center 2800